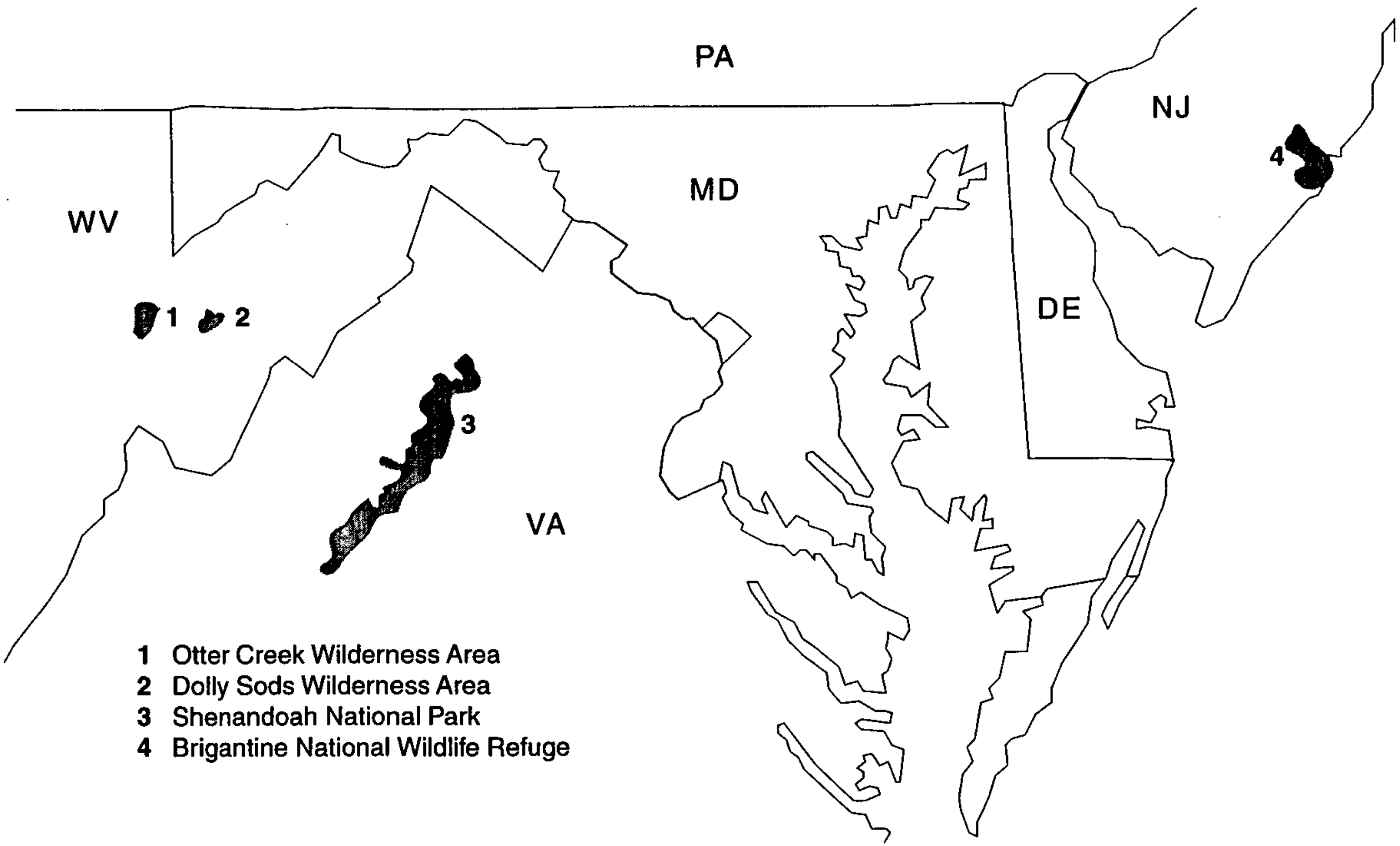
Figure 3-12
Federal Class I Areas in States Surrounding Maryland



3.2.3.3 *Regulatory Ramifications for Utilities*

A variety of regulations have the potential to affect, both directly and indirectly, utilities and their potential contribution to adverse visibility effects. Several portions of the CAA Amendments of 1990 address pollutants, such as SO_2, VOCs, and NO_x, that are responsible for visibility impairment.

The ozone nonattainment provisions in Title I of the CAA include provisions that will reduce the precursor pollutants responsible for urban smog or ozone. Because Maryland is in the Northeast Ozone Transport Region, any utility proposing to expand or build a new power plant in Maryland must address ozone nonattainment regulations. States, such as Maryland, with a "serious" or worse ozone nonattainment area (see Figure 3-4) are required to achieve a 15% reduction in VOC emissions in that area from 1990 levels by 1996, and a 3% reduction (in VOC or NO_x emissions) every year thereafter until attainment is achieved. One of the ways state air quality agencies will achieve these reductions is by requiring stationary pollution sources such as power plants to install stricter control technologies (i.e., Reasonably Available Control Technology; see Section 3.2.1.3). Also, new major sources are required to offset their NO_x and/or VOC emissions with greater emissions reductions at existing sources.

The CAA acid rain provisions in Title IV call for significant reductions of emissions of acid rain precursors through an innovative program involving the buying, selling, and trading of SO_2 emissions allowances (discussed in Section 3.2.2.1). Because Title IV will require utilities to reduce emissions of SO_2 and NO_x, both precursors of visibility-degrading pollutants (i.e., sulfates and nitrates), these new CAA provisions have significant potential to help improve regional visibility.

Finally, Section 169B(c) of the 1990 CAA Amendments mandates that the U.S. EPA establish Visibility Transport Regions (VTRs), consisting of one or more states whose air emission sources appear to contribute significantly to visibility reductions at Class I areas. Presently, no VTRs exist other than for the Grand Canyon. There are currently plans to form the Southern Appalachian Mountains Initiative to address, among other topics, visibility effects at areas throughout the southern Appalachian Mountains, including Shenandoah National Park (Polkowsky 1994). Virginia and West Virginia are the northernmost states involved in this initiative.

3.3 *WATER IMPACTS*

In addition to affecting air quality, construction and operation of power plants have impacts on Maryland's surface water and ground water resources.

3.3.1 *Surface Water Impacts*

Steam generating power plants use large volumes of water for cooling. In Maryland, the Chesapeake Bay is the major source of this water. The Bay also receives most of the effluents, or wastewater discharge, from power plants in the state. Both withdrawal and discharge of water at power plants can adversely affect surface waters.

Hydroelectric power plants also use vast amounts of water. These plants use impounded water produced by the damming of rivers to generate electricity. Inundation of land, blockage of rivers, and changes in water quality both upstream and downstream may result from construction and operation of these facilities.

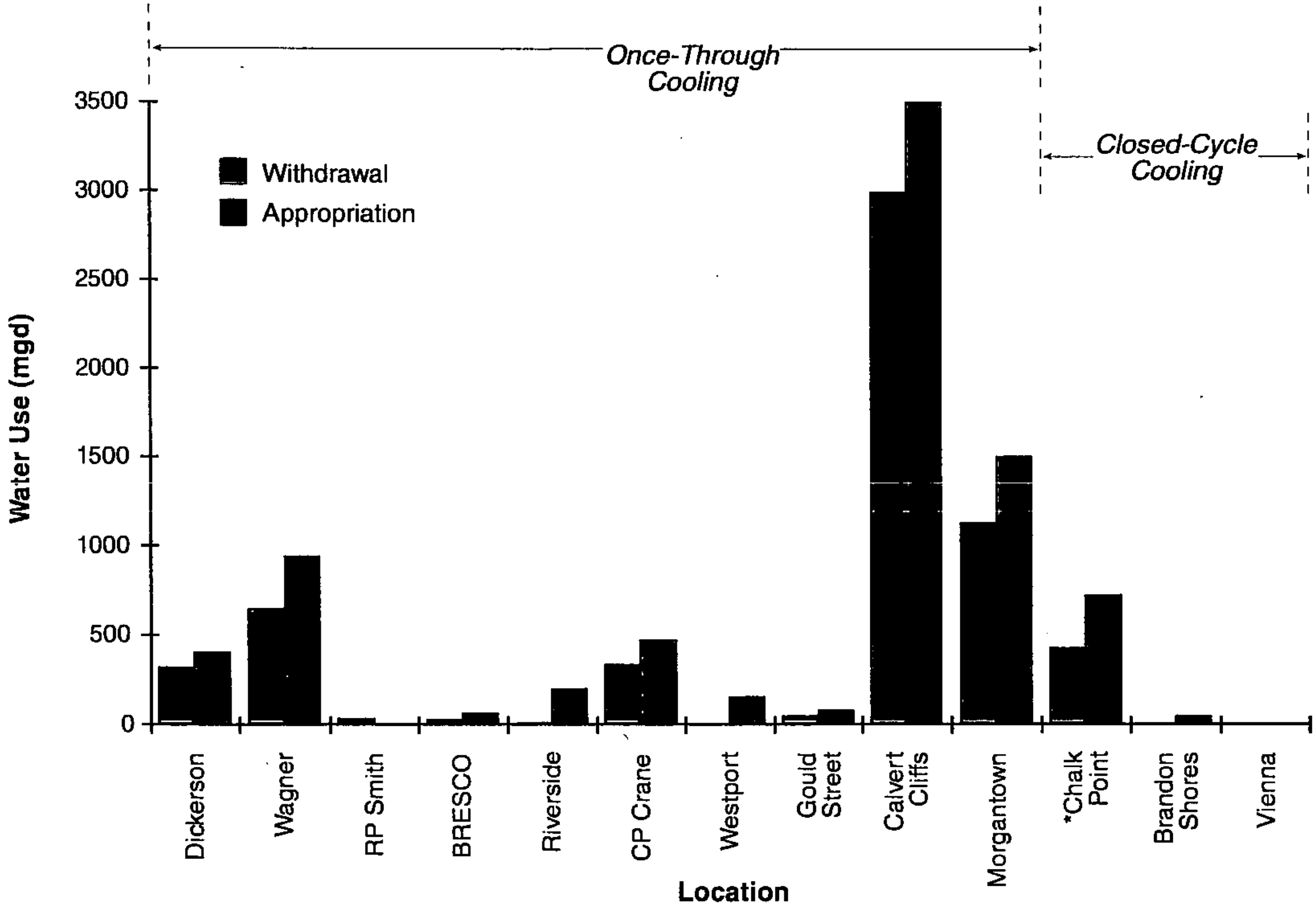
This section focuses on the nature and extent of surface water impacts from these two types of power plants found in Maryland.

3.3.1.1 *Water Withdrawal and Consumption*

Steam generating power plants need water to cool operating equipment. In a **once-through cooling system**, water is drawn continuously into a power plant from a **source water body** and is used to draw the heat from the power plant condensers. This heated water is then discharged into a **receiving water body** (usually the same as the source). Once-through cooling systems require large volumes of water — a fossil fuel-fired plant with once-through cooling uses about 1.4 million gallons of cooling water per day for each MW of electricity produced. Nuclear power plants, such as the Calvert Cliffs plant, generate more waste heat than fossil fuel plants and therefore must use more water per MW for once-through cooling.

With the exception of Brandon Shores, Vienna, and two of the four units at Chalk Point, all of Maryland's steam generating power plants use once-through cooling systems. Figure 3-13 shows water use rates of power plants in Maryland, given in millions of gallons per day (mgd). The surface water appropriation for each power plant is based on a forecast of the plant's water needs over a period of several years. This permitted withdrawal, also shown on Figure 3-13, represents the estimated maximum amount of water that each plant will withdraw.

Figure 3-13
Surface Water Withdrawals (mgd) 1994



Source: Maryland DNR Water Resources Administration

* Chalk Point utilizes both once-through and closed-cycle cooling (2 units on each type of system).

Closed-cycle systems are used at three major Maryland power plants: Brandon Shores, Chalk Point, and Vienna. These systems recycle cooling water and typically require only 2 to 25% of the water needed for once-through cooling systems. However, as much as half of the water withdrawn is **consumed** (used and not returned) due to evaporation. Steam electric plants in Maryland consume nearly 70% of the total freshwater consumed in the state by all sources. As older power plants are replaced, more closed-cycle systems, as well as **dry cooling towers,** may be used to dissipate waste heat at new power plants. Use of closed-cycle systems will result in decreases in total amounts of water withdrawn (and discharged), but could also increase the amount of water consumed due to evaporation.

3.3.1.2 *Impacts of Steam Electric Power Plants*

In Maryland, most cooling water is drawn from the Chesapeake Bay or one of its tributaries. Although there is ample water available in the Bay for cooling purposes, adverse environmental effects can result from withdrawing, heating, and discharging such large volumes of water. The ways in which aquatic organisms are impacted by power plant operations include **entrapment**, **impingement**, **entrainment**, and **discharge effects** (see Table 3-5). Figure 3-14 illustrates where these impacts occur.

Any new thermal discharges and withdrawals of water for cooling purposes must comply with state water quality regulations administered by MDE. MDE regulations allow a certain area within the receiving water body in which thermal discharges may mix (a mixing zone). State water quality criteria must be met outside of this area. Utilities must demonstrate that thermal discharges comply with the mixing zone criteria and that the discharges do not violate state water quality criteria outside the mixing zone. Thermal discharges that cannot comply with the mixing zone criteria are permitted only if the utility can demonstrate that the regulations are more stringent than necessary to protect aquatic biota.

PPRP and Maryland's utilities have evaluated impacts at 12 major power plants in the state over the last two decades, conducting several dozen studies on the nature and extent of entrainment, impingement, and discharge effects. Table 3-5 summarizes the key findings for each power plant. These studies were used to evaluate the relative impacts of power plant operations on the aquatic environment in the state, with special emphasis on the Chesapeake Bay. Some studies were also used as the basis for modifying operating procedures at the plants to minimize impacts and to provide dollar cost estimates of unavoidable losses in aquatic biota.

Figure 3-14
Water Flow Through a Power Plant Using Once-through Cooling

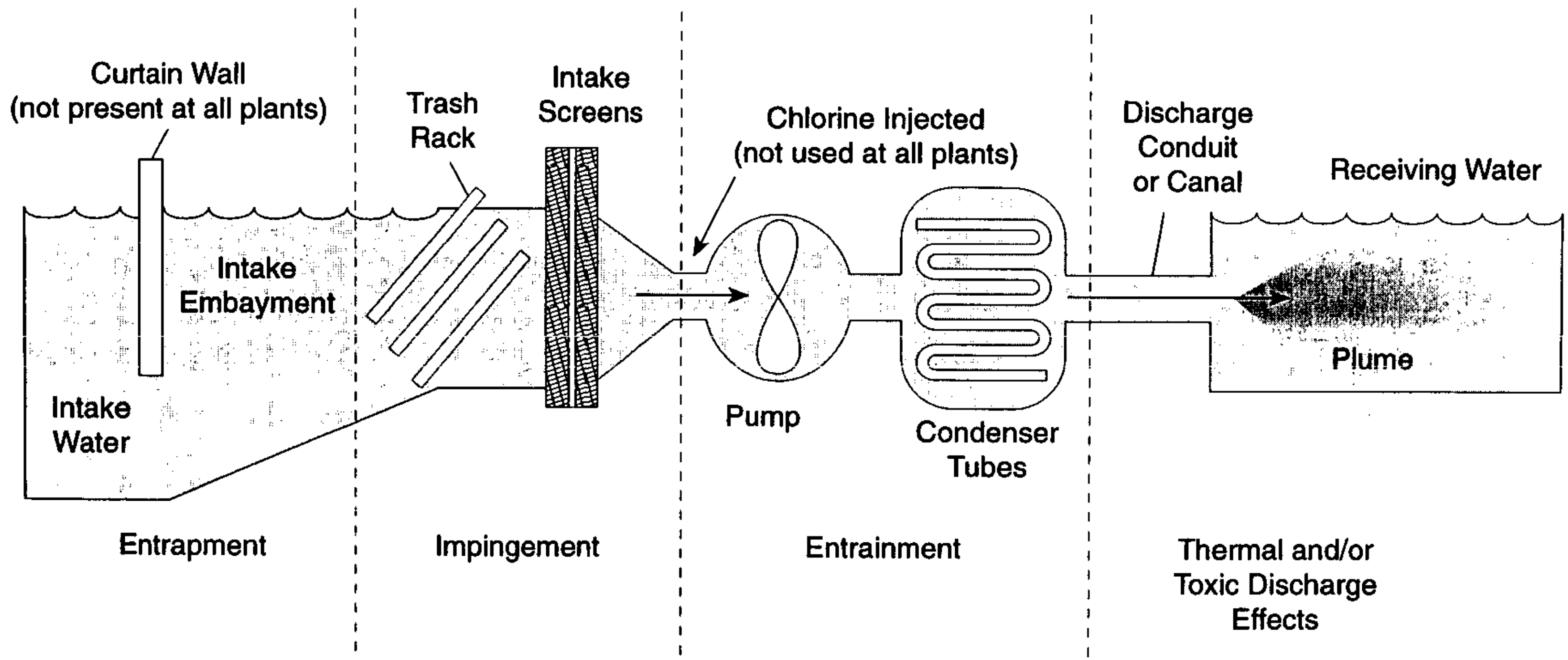


Table 3-5 ***Summary of Entrainment, Impingement, and Discharge Effects at Maryland Power Plants***

Plant: Salinity Zone	Entrainment	Impingement	Discharge
Brandon Shores: Mesohaline - Oligohaline	Not studied; uses closed-cycle cooling, which minimizes impacts	Not studied	Discharge combined with Wagner's larger once-through discharge; no adverse impact from Brandon Shores anticipated
BRESCO Mesohaline - Oligohaline	Phytoplankton and zooplankton entrainment small	Fish impingement count 40% menhaden, 26% mummichogs, 13% silversides, 8% bay anchovies; invertebrates 66% blue crabs, 8% grass shrimp; blue crab impingement value $2700 annually (1987 dollars)	Fails mixing zone criteria but no adverse impact detectable
Calvert Cliffs: Mesohaline	Variable; highest in summer	Bay anchovy, spot, menhaden, hogchoker, blue crabs dominate impingement count	Passes mixing zone criteria; habitat modification in vicinity of discharge
Chalk Point: Mesohaline - Oligohaline	20% decline in phytoplankton between intake and discharge; 8% loss in productivity modeled; 10-20% likely loss of bay anchovy in Patuxent; mitigation implemented for losses of bay anchovy	Menhaden dominate count; barrier nets installed to reduce effects	Fails mixing zone criteria; habitat modification in vicinity of discharge
C.P. Crane: Oligohaline - Tidal freshwater	Ichthyoplankton losses high locally but regional impacts small	Significant number of menhaden, white perch, blue crabs impinged but less than at mesohaline plants	Fails mixing zone criteria; alternate effluent limitations approved; 40% of local volume affected with some effect on salinity, temperature, and bottom-dwellers
Dickerson: Riverine	Losses small; unlikely to have regional consequences	Negligible	Fails mixing zone criteria under some flow conditions; changes in benthos measurable but impacts largely due to water quality degradation much greater than power plant impacts
Gould Street: Mesohaline - Oligohaline	Phytoplankton and zooplankton entrainment not studied	Not studied	Passes mixing zone criteria; discharge effects not studied
Morgantown: Mesohaline - Oligohaline	Variable; highest in summer	Occasionally high impingement episodes	Passes mixing zone criteria; habitat modification in discharge
Riverside: Mesohaline - Oligohaline	Phytoplankton and zooplankton entrainment not studied	Not studied	Passes mixing zone criteria; discharge effects not studied

Table 3-5 Summary of Entrainment, Impingement, and Discharge Effects at Maryland Power Plants (continued)

Plant: Salinity Zone	Entrainment	Impingement	Discharge
R.P. Smith: Riverine	Losses small; unlikely to have regional consequences	Losses < $500 annually (1980 dollars)	Fails mixing zone criteria under some flow conditions; changes in benthos measurable but impacts due to water quality degradation much greater than power plant impacts
Wagner: Mesohaline - Oligohaline	Early model results showed potentially significant impacts; evaluation of 1993 field studies indicate impact is minimal	Not studied	Fails mixing zone criteria; discharge effects difficult to measure due to presence of other facilities and 3 layer circulation in Harbor

3.3.1.3 *Impacts within Habitat Types*

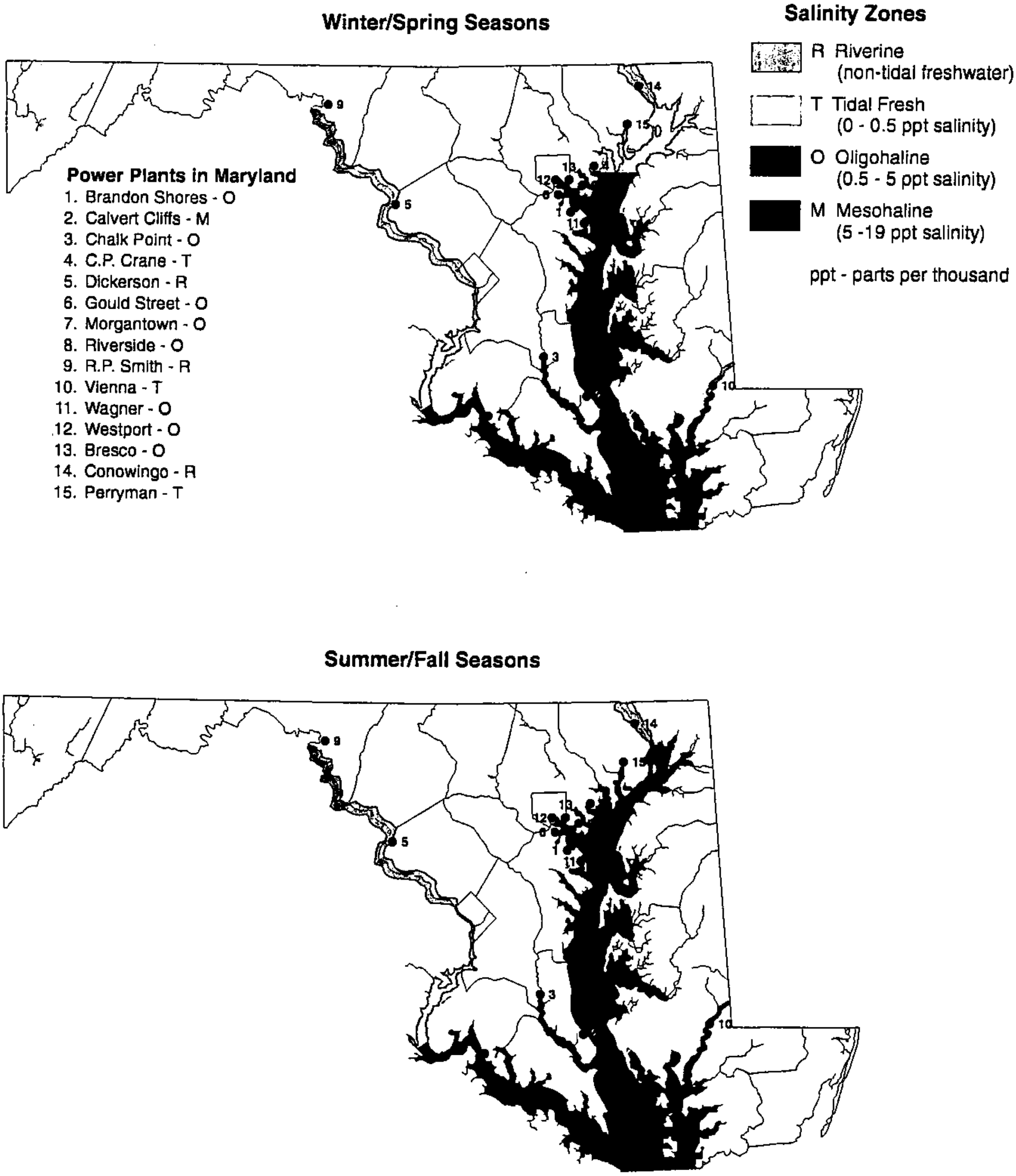
Several **habitat types** exist in the Chesapeake Bay, which are defined by salinity zones (Figure 3-15). Each habitat type supports a different mix of biological communities. Each community will react differently to the stresses of entrainment, impingement, and discharge effects; consequently, the impact of power plant operations varies among habitat types. Results of PPRP's many impact studies are summarized below by salinity zone.

Mesohaline Zone (Lower Bay)

Results of studies at all power plants in the **mesohaline** zone, which is a primary shellfish production area, show that there have been no cumulative impacts to aquatic resources to date. Although large entrainment losses of some types of aquatic organisms, known as phytoplankton and zooplankton, have been measured frequently, no consistent depletions in numbers of organisms have been found. This is most likely due to the fact that these small organisms have short generation times (hours to days), and therefore populations recover quickly from entrainment.

The only power plants in this type of habitat that may affect riverwide fish spawning and nursery areas are Chalk Point and Wagner. At Chalk Point, this potential loss is being mitigated with a program to rear and stock fish in the Patuxent River and to remove blockages to migratory fish. At Wagner (located in Baltimore's outer harbor), data from recent field studies indicate that entrainment impacts are much smaller than

Figure 3-15
Salinity Zones of the Maryland Chesapeake Bay



previously believed. Based on these results it appears that mitigative measures may not be warranted. Power plants in the mesohaline zone impinge large numbers of juvenile fish and crabs; however, fish and crab losses do not cause measurable depletions in these species because of the large size and wide distribution of their populations.

Tidal Fresh - Oligohaline Zones

Studies indicate that entrainment losses from power plants in these zones, which are spawning areas for some fish such as striped bass and white perch, are small and do not affect regional populations. Many organisms in these habitats survive impingement; the major species that are impinged are abundant throughout Maryland's tidal waters. Impingement losses are too small to have a detectable effect on regional fish populations.

Riverine (Non-tidal Freshwater) Zone

Studies in this habitat zone, which is a major spawning area for many types of fish, have shown that, in general, entrainment and impingement impacts are small. There are some discharge effects in this habitat, but they are localized. None of the studies have identified long-term cumulative impacts from these facilities.

3.3.1.4 *Reducing Aquatic Impacts*

Numerous **intake technologies** and modifications to operating practices have been developed to reduce entrainment or impingement impacts at steam electric power plants (Ray *et al.* 1976; Cannon *et al.* 1979; McGroddy and Matousek 1989). However, relatively few have the ability to reduce both entrainment and impingement impacts. PPRP has investigated the applicability of several intake technologies to Maryland's power plants and ecosystems.

Intake technologies can be classified into three categories: **physical barriers, behavioral barriers**, and **collection**. Physical barriers, such as screens or nets, are the most successful for reducing both entrainment and impingement.

Barrier nets are generally economical to install and maintain, particularly for retrofitting at older plants. Nets reduce impingement effectively in both estuarine and freshwater habitats. Chalk Point has a barrier net across the mouth of its intake canal, but physical limitations at other Maryland power plants, such as Morgantown or Calvert Cliffs, may prevent installation there (Wietz 1981). Wedge-wire screens are moderately expensive to retrofit into existing power plants or to install into new plants. Their fine wire mesh keeps entrainment low and essentially eliminates impingement (Heuer and Tomljanovich 1978; Hanson 1981; Weisberg *et al.* 1984a). However, small spacing makes the screens susceptible to clogging due to biofouling; air backflushing minimizes this problem (Weisberg *et al.* 1984b). Wedge-wire screens are successfully employed on the Delaware River and are currently being incorporated in the design of the proposed Dorchester power plant in Maryland.

Behavioral barriers, such as air bubble curtains and sound, are designed to cause fish to avoid intake flows. These barriers have been found to be moderately effective in reducing impingement of schooling fish, but are unsuccessful for protecting other types of fish from impingement, or at reducing entrainment and impingement of fish in early life stages (Lieberman and Muessig 1978; Cannon *et al.* 1979; Hocutt 1980; Hames and Patrick 1986).

Collection of organisms after impingement is only partially effective at reducing impingement losses. Some of the collected organisms, particularly those in early life stages and juveniles, are sensitive to handling and abrasion and suffer high post-impingement mortality (Tatham *et al.* 1977). If impinged organisms are returned to the receiving water body near the intake structure, they may be susceptible to reimpingement. PEPCO has redesigned the fish return system at its Morgantown plant to be capable of returning fish to either side of the intake structure depending on the direction of the tide, thus reducing the potential for reimpingement. Similarly, the fish return system installed at BGE's Wagner power plant places impinged fish into a channel leading away from the intake screens.

Modification of plant operations is frequently the most cost-effective approach for reducing many aquatic impacts. Two operating practices that PPRP has evaluated are modifications to **intake screen wash cycles** and the use of **auxiliary tempering pumps**. To clean intake screens of impinged debris and organisms, intake screens at Maryland power plants are rotated on a frequency of anywhere from once per day to continuously. Increasing the frequency of rotation does not alter the rate of impingement, but it can have the beneficial effect of reducing mortalities associated with impingement by reducing the amount of time organisms are exposed to scavengers (e.g., crabs) and conditions leading to suffocation (Tatham *et al.* 1977).

Auxiliary tempering pumps were used at Chalk Point until the 1980s. This type of system withdraws surface water to mix with the plant's discharge and to decrease the effects of thermal and chemical water discharges. Studies by both PEPCO and PPRP, however, showed that turning off the pumps would reduce entrainment and impingement while not increasing downstream mortalities significantly (Cadman and Holland 1986). PEPCO has now discontinued use of the pumps.

3.3.1.5 *Impacts of Hydroelectric Facilities*

Nine hydroelectric projects are operating in Maryland (Table 3-6). The largest facility in Maryland is the Conowingo Hydroelectric Station, with a capacity of 512 MW. The second largest is Deep Creek Station, with a capacity of 19.2 MW. Seven smaller projects around the state have a combined capacity of 3 MW. The development and operation of hydroelectric facilities can cause three types of impacts — alteration of water quality, fluctuations in water level and flow, and prevention of fish passage.

- *Alterations of water quality* - Hydroelectric generation can affect water clarity, dissolved oxygen (DO) concentration, and water temperature both upstream and downstream of the dam (Areas A and D in Figure 3-16).
- *Fluctuations in water level and flow reductions* - Operating hydroelectric facilities in a **peaking mode** (that is, not continually but in response to peak demand for electricity) produces unnatural, and frequently extreme, water level fluctuations in impoundments and in aquatic habitats downstream of dams (Areas A and D, Figure 3-16). Small-scale hydroelectric projects may also divert some streamflow away from the natural streambed. Fluctuations in water level and flow may interfere with recreational use of the water body and reduce the abundance of food important to fish growth and survival.
- *Prevention of fish passage* - Hydroelectric development can prevent the movement of both resident and anadromous fish species past the dam (Areas B and C, Figure 3-16). Entrainment through turbines may kill many fish, depending on the type of turbine, the proportion of flow diverted through the turbine, and the size of fish passing downstream.

Figure 3-16
Water Flow Through a Hydroelectric Plant

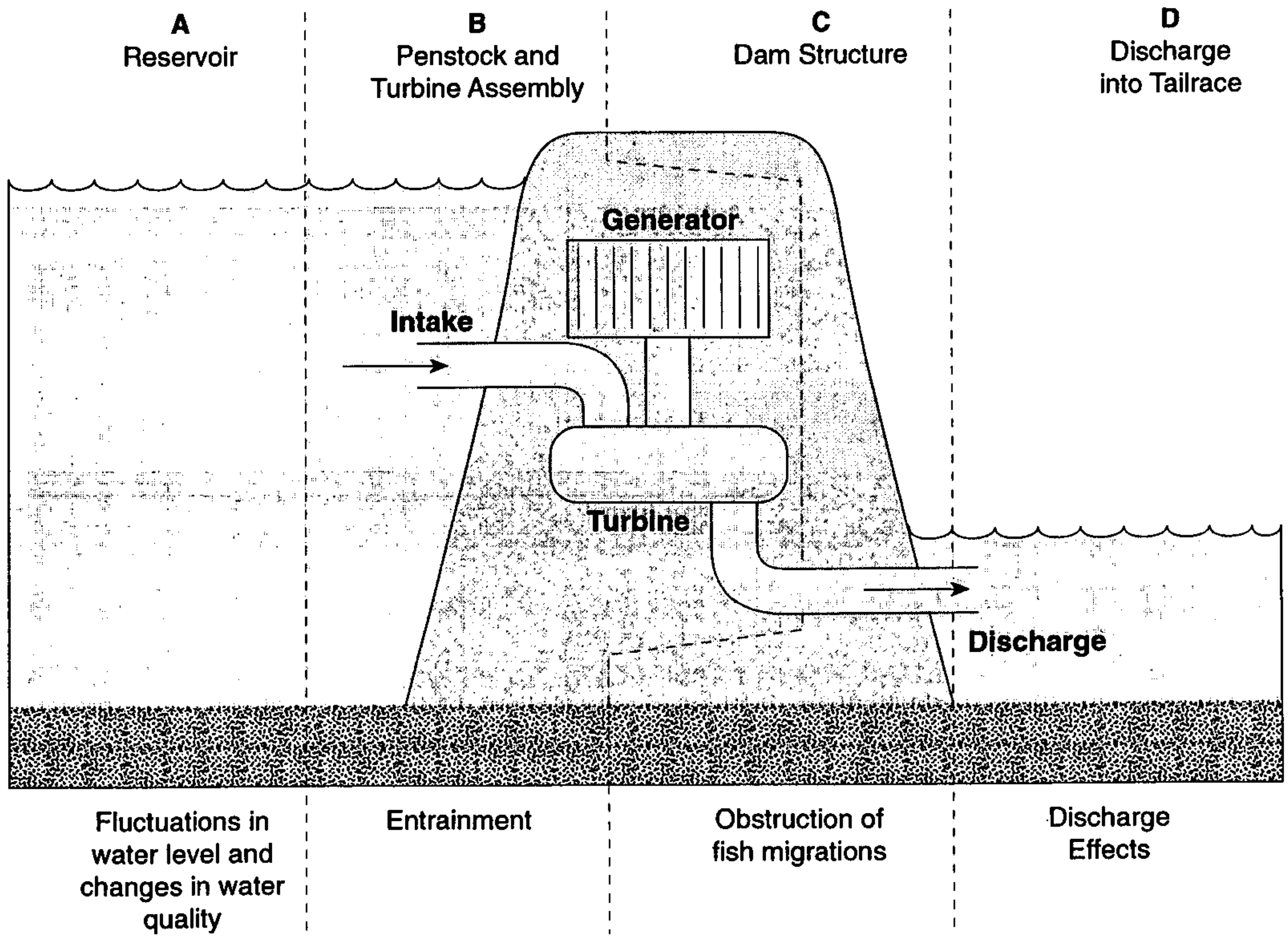


Table 3-6 Operational Hydroelectric Projects in Maryland

Project	Project Capacity (kw)	River/ Location	FERC Docket No.	Owner	License Type	Issued	Expires	Year Operational
Gilpin Falls	396	Northeast Creek/ Pleasant Hill, Cecil County	3705	American Hydropower Company	License exemption	1982	—	1984
Wilson Mill	23	Deer Creek/ Darlington, Harford County	—	A. Thadani	None	—	—	1983
Gores Mill	10	Little Falls/Baltimore County	—	C. Lintz	None	—	—	1950s
Parker Pond	40	Beaver Dam Creek/Wicomico County	—	W.H. Hinman	None	—	—	1950s
Potomac Dam #5	1,120	Potomac River/ Clear Spring, Washington County	2517	PE	Major license	1976	2003	1919
Potomac Dam #4	1,000	Potomac River/ Shepherdstown, WV	2516	PE	Major license	1965	2003	1909
Deep Creek	19,200	Youghiogheny/ Garrett County	2370	Penelec	None	—	—	1925
Brighton	400	Patuxent River/ Clarksville, Montgomery County	3633	Alternative Energy Associates Limited Partnership	Minor license	1984	2024	1986
Conowingo	512,000	Susquehanna River/ Cecil, Harford County	405	PECO	Major license	1980	2014 ~~2004~~	1928

In Maryland, there are two general concerns about fish passage through hydroelectric facilities: 1) interruption of the migratory patterns of fish (primarily shad, herrings, and striped bass) that swim upstream to reproduce; and 2) fish mortality in the turbines, which can reduce resident fish populations. Studies to date on fish passage at small facilities in Maryland have only been conducted where resident fish were of concern. These studies indicate that there is some turbine-related mortality of fish. However, the magnitude of this effect varies between sites, indicating the need for evaluation at each project.

Small-scale hydroelectric projects in Maryland undergo a review process that allows for early involvement by state resource agencies. By this means, PPRP has been able to work with developers to mitigate potential impacts before a hydroelectric plant is constructed. Where potential impacts could not be addressed fully before construction, monitoring programs to measure the degree of impact have been required of the developer or conducted by PPRP.

The state has devoted substantial study to potential impacts of the Conowingo hydroelectric station on the Susquehanna River operated by PECO. Significant stocks of resident and anadromous fish species, such as channel catfish, white perch, and striped bass, occur downstream of the dam. Historically, the Susquehanna River supported large spawning runs of anadromous species such as American shad and river herring. Sport fishermen regularly visit the region, and surveys suggest that the area has been one of the most intensively fished locations in the state.

Dam operations at Conowingo control water levels and flows in downstream aquatic habitats, thereby directly affecting the abundance and type of food organisms available for fish. During peak electricity demand periods in the summer, river water upstream of the dam if released unconditioned, often has low DO concentrations, which can cause poor water quality downstream of the dam. The dam has also prevented anadromous fish from reaching spawning areas upstream. After many years of negotiation, the Federal Energy Regulatory Commission (FERC), the State of Maryland, and PECO reached agreement in 1988 to address these problems in three broad areas:

- *Water Quality* - PECO evaluated several methods to improve DO in water released from Conowingo and selected turbine venting as the most effective and feasible. PPRP conducted studies in cooperation with PECO to evaluate the effectiveness of turbine venting. To date, venting has proven effective in providing water below the dam that meets Maryland's DO standard.
- *Water Flow and Downstream Habitat* - As a result of studies which showed that a minimum flow could improve fish habitat below the dam, PECO agreed to provide minimum flows all year. The amount of flow is seasonal, varying from a high of 10,000 cubic feet per second (cfs) in the spring to 3,500 cfs in the winter. Providing minimum flows year round represents a significant cost to the utility because it requires shifting some power generation to nights and weekends when the demand for electricity and economic payback is significantly lower. PPRP has also studied the need for providing continuous flows during the winter months (December through February) and found that the risks to biological resources were minimal during those months. Modification of minimum flows required during the winter is currently under consideration.
- *Anadromous Fish Restoration* - In the 1970s, PECO installed an experimental fish lift at Conowingo in response to concerns about restoring anadromous fish runs upstream of the dam. By 1989, PECO had collected more than 8,000 adult shad at the lift. Most of the fish were transported by truck to upstream spawning grounds because passage was not possible at the dams upstream of Conowingo. Due

to the success of the experimental fish lift, PECO, FERC, and Maryland and Pennsylvania resource agencies agreed on permanent fish passage at Conowingo. Construction of the new east side fish lift was completed in the spring of 1991, in time for the spring shad run. PECO collected 27,227, 25,721, 13,546, 32,330, and 61,650 American shad in the 1991, 1992, 1993, 1994, and 1995 runs, respectively (Figure 3-17; SRAFRC 1995).

The ultimate goal of the resource agencies was to establish fish passage at dams upstream of Conowingo as well — Holtwood, Safe Harbor, and York Haven hydroelectric facilities — and stop transporting shad by truck. A breakthrough in achieving this goal and in enhancing the recovery of the American shad and other migratory species that live in the Chesapeake Bay and the Susquehanna River was reached in October 1992 (Brown 1992; Blankenship 1992). After many years of negotiations with Maryland DNR, the U.S. Fish and Wildlife Service, the Pennsylvania Fish and Boat Commission, and other groups, Safe Harbor Water Power Corporation and Pennsylvania Power and Light (which owns Holtwood) agreed to build fish passage facilities at their two hydroelectric facilities on the Susquehanna River by 1997 (Figure 3-18). Metropolitan Edison (a subsidiary of General Public Utilities), which operates the York Haven Dam further upstream, will also construct a passage facility to be operational by the year 2000.

This agreement is the result of protracted industry and governmental negotiations that have been going on for over a decade. The agreement will sustain and enhance the restoration of the American shad populations in the Chesapeake Bay and the Susquehanna River by opening more than 1,000 miles of spawning habitat in the basin. The fish passage facilities will allow shad and other migratory species of fish to travel over the dams during their annual journey upriver from the Atlantic Ocean via the Bay.

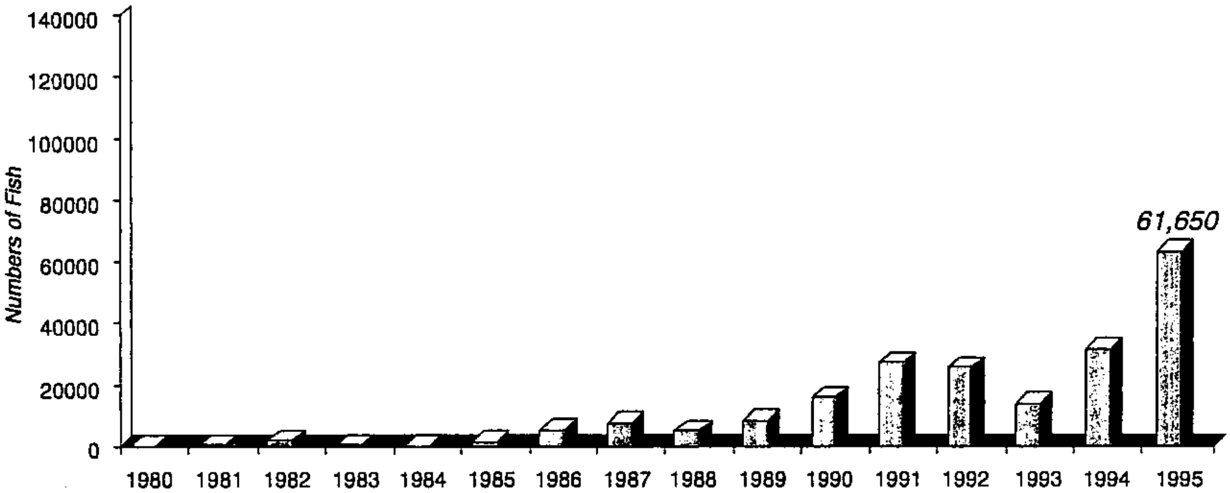
3.3.1.6 *Deep Creek Hydroelectric Station*

The Deep Creek hydroelectric project is a 19.2-MW facility located in Garrett County and owned by Penelec. Deep Creek Lake, a 3,900-acre impoundment created specifically for hydroelectric generation in the 1920s and owned by Penelec, has evolved as the centerpiece of tourism in western Maryland. Discharges from the Deep Creek project enter Maryland's only designated "wild" river, the Youghiogheny, which supports a developing trout fishery, a number of rare or endangered plants and animals, and one of the most challenging kayaking and canoeing runs in the United States.

In 1988, Penelec initiated renewal of the Deep Creek facility's license with FERC. As the coordinating agency for the state, PPRP was involved at the

Figure 3-17
Numbers of American Shad

Shad Collected



Shad in Upper Bay

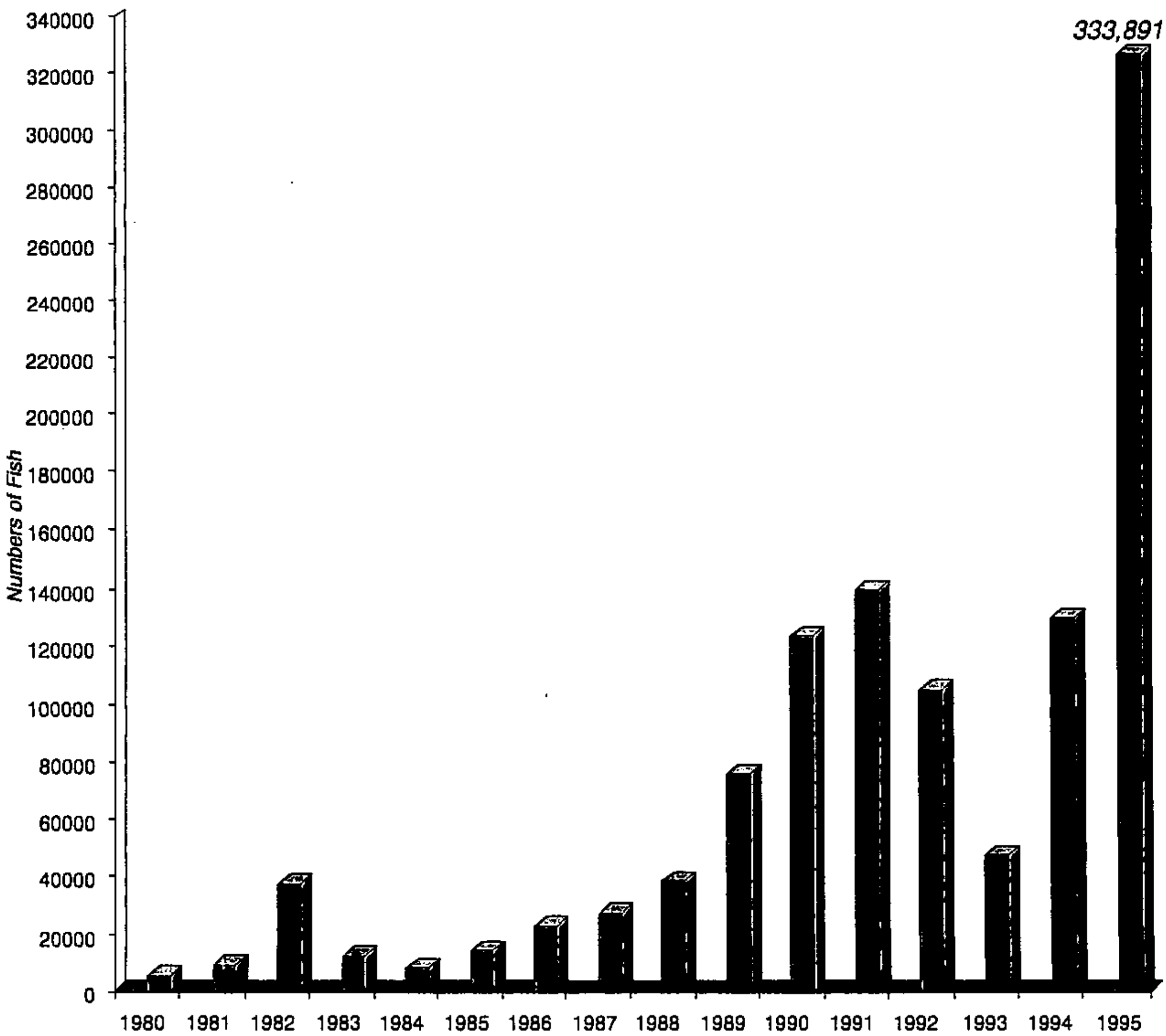
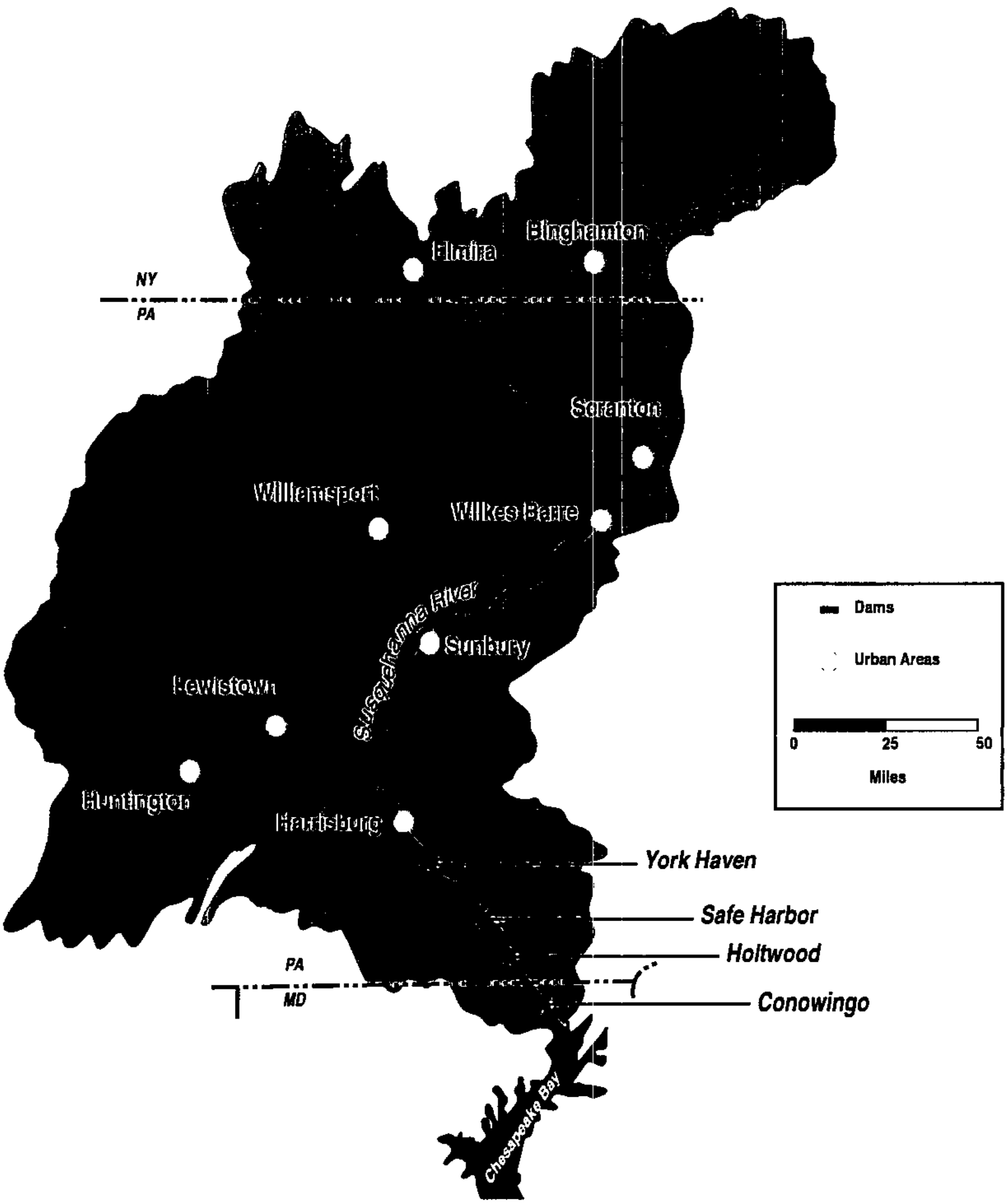


Figure 3-18
The Susquehanna River Watershed and Mainstream Hydroelectric Stations



outset of the relicensing and consultation process. PPRP identified issues of concern and conducted necessary environmental studies in close cooperation with Penelec. The relicensing presented an opportunity to develop and implement a plan for controlling the timing and quantity of water released from the project to satisfy two objectives: 1) providing a reliable source of electricity, and 2) enhancing lake and river natural and recreational resources. This required finding balanced solutions to a variety of technically complex problems, because the interests of various users of Deep Creek Lake's resources are often conflicting.

In late 1991, Penelec was released from FERC jurisdiction (effective in 1994) and is now operating with a State surface water appropriations permit. PPRP has continued its involvement, providing technical expertise to produce an equitable plan for future water and resource management at the project (Penelec 1991). The water appropriations permit issued to Penelec in 1994 included conditions to balance the following suite of conflicting natural resource and recreational concerns: 1) reservoir operations to make lake-based recreational opportunities more dependable and extend further into autumn, 2) operation of the project to increase the number and dependability of whitewater boating opportunities, 3) mitigation of a long-standing DO problem in project discharges, 4) maintenance of a continuous minimum flow in the river to increase trout habitat, and 5) timing of generation during summer to maintain coldwater habitat for trout on a year-round basis. When fully implemented, these changes to the Deep Creek Lake project will produce substantial economic, environmental, and recreational benefits to one of Maryland's most valuable natural resources.

3.3.1.7 Chalk Point Mitigation

The Patuxent River drainage is of special interest and concern to the State of Maryland because it is the largest river drainage contained entirely within Maryland's borders. Recent improvements in water quality (Magnien *et al.* 1993) have increased the amount of potential fisheries habitat within the river and its tributaries. In 1991, the State of Maryland and PEPCO reached an agreement specifying that PEPCO would provide some measure of compensation for the loss of forage finfish resulting from entrainment at the Chalk Point station. Specific conditions of this agreement included: 1) funding for production and stocking of striped bass and American shad, and 2) removal of obstructions to migratory fish in the Patuxent River tributaries.

The first objective was already being partially addressed by PEPCO's aquaculture facility at Chalk Point, where PEPCO rears juvenile striped bass and American shad hatched at DNR's Manning hatchery. Since 1985, over 3 million striped bass were produced and 2.8 million of these were released in the Patuxent River. Since 1990, over 200,000 American shad were produced, all of which were stocked in the Patuxent River.

The obstruction removal program is designed to provide anadromous fish access to upstream habitats (O'Dell and Mowrer 1984). An evaluation of stream obstructions was conducted during the summer of 1991. Twelve sites were selected as priority barriers to fish passage (Table 3-7); another site, waterfalls on the Little Patuxent River, will also be evaluated for feasibility of providing fish passage. These sites are all at various stages of preliminary investigation, engineering surveys, conceptual design, detailed design, and construction. Based upon completed conceptual design plans, steep-pass fishways were identified as being needed for three fish passage projects, and purchase of pre-fabricated fishways has been initiated.

Table 3-7 Fish Passage Priorities for Patuxent River Drainage

	Stream	Type of Barrier	Road Location	Stream Mile Location	Affected Species	Est. Fish Passage Cost ($)	Proposed Type of Passage or Action
1.	Towser's Branch	Pipe Culvert	Evergreen Road	0.8	H, WP, O	35,000-50,000	Weir or steep-pass
2.	Towser's Branch	Pipe Culvert	Brickhead Road	1.2	H, WP, O	25,000-50,000	Weir, steep-pass or culvert replacement
3.	Dorsey Run	Railroad Trestle and Culvert	At railroad bridge 1/10 mile down from Rt. 32	0.8	Unknown	10,000-25,000	Trestle removed October 1994; culvert replaced January 1994
4.	Midway Branch	Pipe Culvert	At Boundary Trail in Fort Meade	0.9	H, O	25,000-50,000	Weir or steep-pass
5.	Horsepen Branch	Dam	1/10 mile downstream from Bowie Race Track Road	0.4	WP, O	75,000-125,000	Steep-pass or removal
6.	Mill Branch	Pipe Culvert	Rt. 301	2.1	H, O	25,000-50,000	Weir or steep-pass
7.	Unnamed Stream	Dam	0.5 mile downstream from Sands Road	0.3	Unknown	50,000-100,000	Steep-pass or removal
8.	Unnamed Stream	Pipe Culvert	Sands Road	0.8	Unknown	20,000-35,000	Weir or steep-pass
9.	Unnamed Stream	Pipe Culvert	Sands Road	1.3	Unknown	25,000-50,000	Weir or steep-pass
10.	Charles Branch	Box Culvert	Croom Station Road	2.7	H, WP, O	25,000-50,000	Weir or steep-pass
11.	Walker Branch	Dam	Brooklyn Bridge Road	0.2	Unknown	150,000-200,000	Steep-pass or removal
12.	Western Branch	Dam	0.4 mile downstream from Rt. 214	13.4	H, O	100,000-150,000	Removed October 1994
13.	Little Patuxent River*	Waterfalls	0.5 mile upstream from Savage	20.1	H, O	200,000-300,000	Pool and weir or other fishway, if feasible

* Project may be performed if technically feasible.

<u>Species Key:</u>

H- River Herring

WP- White Perch

O- Other Migratory Species

Unknown- Sampling Not Performed

3.3.2 *Ground Water Impacts*

In addition to affecting surface water resources, the siting, operation, and expansion of power plants have the potential to impact the quantity and quality of ground water resources in Maryland. Some power plants use ground water resources to satisfy their need for high-quality water as boiler feedwater or for emissions control. The significant quantity of ground water used by power plants in the state has raised concerns about whether these withdrawals are lowering ground water levels to an unacceptable extent in critical regional **aquifers**. Ground water withdrawal impacts are managed by MDE's Water Resources Administration. Their overall policy toward ground water appropriations is to conserve and protect water resources of the state in the best interest of the people, providing for the greatest feasible use of waters of the state. Maryland follows the **reasonable use doctrine** to determine a person's right to withdrawal ground water. This policy holds that private property owners have the right to make reasonable use of the waters of the state which cross their land without undue interference with other persons also attempting to make reasonable use of water. Furthermore, a water user may not unreasonably harm the water resources of the state.

The purpose of this section is to update information on the cumulative impacts of Maryland power plants on ground water quantity and quality in the state. Previous CEIRs (e.g., PPRP 1993) provide a framework for evaluating the cumulative ground water impacts of Maryland power plants. The reader is referred to these earlier documents for a more complete understanding of ground water impact.

This report focuses on ground water withdrawals by power plants during 1992 and 1993, and assesses the cumulative impact of these withdrawals on water levels in the aquifers. Information on ground water withdrawal impacts was obtained from a cooperative program between PPRP, the Maryland Geological Survey (MGS), and the United States Geological Survey (USGS). Under this joint program, observation wells near Maryland power plants have been incorporated into a state-wide ground water monitoring network that documents changes in ground water levels near major ground water users. Through this program, data from the Magothy and Patapsco Aquifers have been collected since 1975, and data from the Aquia Aquifer have been collected since 1976.

In addition to ground water withdrawal impacts, the storage and handling of large quantities of fuel oil, coal, and coal combustion by-products typical at power plants has the potential to degrade ground water quality. These ground water quality impacts are also discussed briefly in this report. PPRP has collected information on ground water quality impacts associated with power plants over the past 11 years. A number of site-specific studies have been conducted to evaluate the impacts of particular power plants on ground water quality, and recent results from a few of these studies are presented in this report.

3.3.2.1 *Ground Water Withdrawal Impacts*

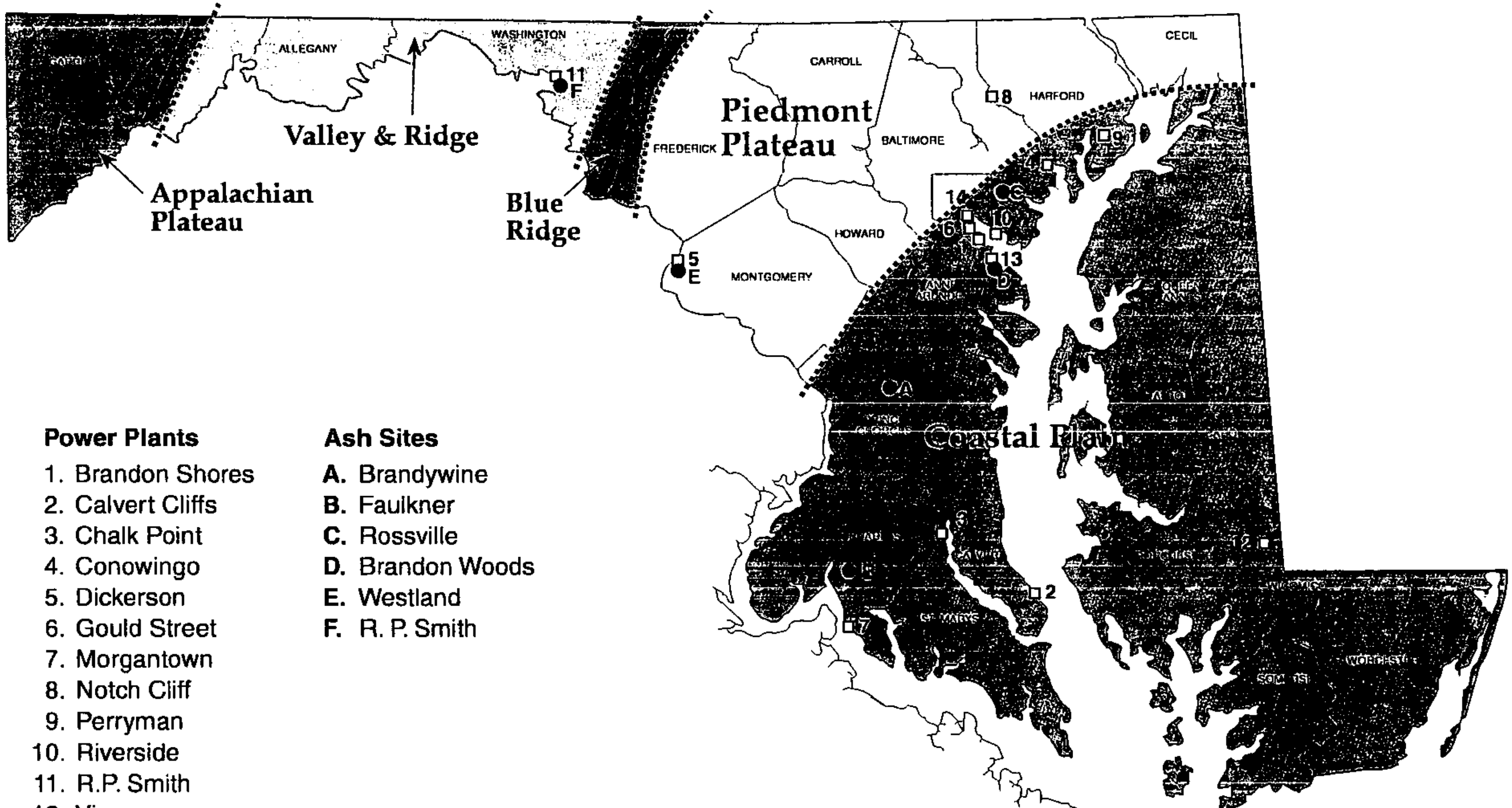
Currently, five power plants use ground water for plant operations. These plants include BGE's Calvert Cliffs Nuclear Power Plant, PEPCO's Chalk Point and Morgantown power plants, Delmarva Power's Vienna Power Plant, and SMECO's combustion turbine (located at the Chalk Point plant). All of these power plants are located in the Coastal Plain of Maryland (Figure 3-19) and withdraw ground water from four major Maryland aquifers: the Columbia Group, the Aquia, the Magothy, and the Patapsco.

Table 3-8 lists ground water withdrawal rates of each of the five power plants from 1975 to 1993, expressed as daily averages; these data are illustrated in Figure 3-20. Table 3-9 provides information on the production wells used at each facility, as well as the nearby observation wells used to evaluate drawdown effects. The average amount of ground water withdrawn in 1992 and 1993 from all five power plants was 1.56 and 1.60 mgd, respectively. By comparison, the combined appropriation limit for daily ground water withdrawals established by the permits for the five plants is 2.66 mgd.

The total average daily withdrawals decreased slightly in 1992 and 1993 relative to 1990 and 1991. The trend in the withdrawal rate in 1992 and 1993 for each plant is summarized below.

- *BGE's Calvert Cliffs Plant* - The withdrawal rates in 1992 and 1993 were similar to the 1991 rate, which was two-fold higher than in 1989 and 1990 when the plant was shut down. However, the withdrawal rates remained below pre-shutdown levels.
- *PEPCO's Morgantown Plant* - The withdrawal rate from the Patapsco Aquifer was consistent with 1990 and 1991 withdrawal rates.
- *Delmarva Power's Vienna Plant* - Withdrawals from the Columbia Group Aquifer increased about two-fold from 1990 and 1991 levels; however, these higher withdrawals were significantly below the levels in the 1970s.
- *PEPCO's Chalk Point Plant* - The ground water withdrawal from the Magothy Aquifer decreased in 1992 and 1993, continuing a trend of decreasing withdrawals since 1989. There was also a slight decrease in the withdrawal from the Patapsco Aquifer in 1992; however, the withdrawal in 1993 was similar to previous years.
- *SMECO's Chalk Point Plant* - The withdrawal rates from the Patapsco Aquifer remained constant compared to the 1990 and 1991 rates.

Figure 3-19
Locations of Existing Maryland Power Plants and Ash Sites in Relation to Physiographic Provinces



Power Plants

1. Brandon Shores
2. Calvert Cliffs
3. Chalk Point
4. Conowingo
5. Dickerson
6. Gould Street
7. Morgantown
8. Notch Cliff
9. Perryman
10. Riverside
11. R.P. Smith
12. Vienna
13. Wagner
14. Westport

Ash Sites

A. Brandywine
B. Faulkner
C. Rossville
D. Brandon Woods
E. Westland
F. R. P. Smith

Table 3-8 *Average Daily Ground Water Withdrawal Rates at Maryland Power Plants (in mgd)*

	Calvert Cliffs (Aquia Aquifer)	Morgantown (Patapsco Aquifer)	Vienna (Columbia Group Aquifer)	Chalk Point (Magothy Aquifer)	SMECO - Chalk Point (Patapsco Aquifer)	Chalk Point (Patapsco Aquifer)	Total Average Daily Withdrawal
Current Appropriations Limit:	0.45	0.82	0.05	0.66	0.66	0.02	2.66
1975	0.23	0.80	0.04	0.75			1.82
1976	0.20	0.80	0.07	0.95			2.02
1977	0.25	0.80	0.06	0.70			1.81
1978	0.23	0.70	0.06	0.70			1.69
1979	0.25	0.80	0.07	0.85			1.97
1980	0.25	0.80	0.04	0.77	0.30		2.16
1981	0.27	0.65	0.02	0.69	0.37		2.00
1982	0.27	0.60	0.02	0.61	0.39		1.89
1983	0.25	0.60	0.03	0.69	0.43		2.00
1984	0.28	0.70	0.03	0.62	0.37		2.00
1985	0.26	0.61	0.03	0.64	0.26		1.80
1986	0.26	0.62	0.02	0.50	0.41		1.81
1987	0.38	0.52	0.03	0.42	0.35		1.70
1988	0.25	0.67	0.03	0.42	0.37		1.74
1989	0.07	0.73	0.04	0.54	0.46		1.84
1990	0.09	0.68	0.02	0.59	0.44	0.01	1.83
1991	0.15	0.57	0.01	0.43	0.46	0.01	1.63
1992	0.15	0.58	0.04	0.37	0.41	0.01	1.56
1993	0.18	0.67	0.03	0.25	0.46	0.01	1.60

Source: U.S. Geological Survey

Figure 3-20
Average Daily Ground Water Withdrawal Rates at Maryland Power Plants

Table 3-9 Production and Observation Wells for Maryland Power Plants Using Ground Water

Power Plant	USGS Well Number	Maryland Permit No.	Well Type	Elevation of Land Surface (feet)	Screen Position Below Sea Level (feet)	Total Depth Drilled (feet)	Aquifer
Calvert Cliffs	CA-Ed 23	72-0041	Production	80	403-527	607	Aquia
	CA-Ed 24	72-0063	Production	100	420-537	640	Aquia
	CA-Ed 25	69-0035	Production	60	445-563	638	Aquia
	CA-Ed 27	69-0037	Observation	62	489-499	585	Aquia
	CA-Ed 47	81-0754	Observation	10	467-513	565	Aquia
Chalk Point	PG-Hf 23	47061	Observation	7	601-606	675	Magothy
	PG-Hf 24	47129	Observation	8	404-409	454	Aquia
	PG-Hf 25	47062	Observation	14	351-357	454	Aquia
	PG-Hf 26	49920	Production	14	591-621	638	Magothy
	PG-Hf 27	49921	Production	16	581-617	650	Magothy
	PG-Hf 28	51271	Production	7	587-616	640	Magothy
	PG-Hf 30	72-0047	Observation	55	340-371	426	Aquia
	PG-Hf 31	73-0065	Observation	11	996-1023; 1505-1530	2453	Patapsco - 1000 & 1500 foot sand
	PG-Hf 32	73-0065	Observation	11	1514-1519	1545	Patapsco - 1500 foot sand
	PG-Hf 33	73-0065	Production	11	585-628	639	Magothy
	PG-Hf 35	72-0086	Observation	11	388-419	430	Aquia
	PG-Hf 36	73-0140	Production	12	593-622	634	Magothy
	PG-Hf 38	73-0172	Production	12	952-1054	1066	Patapsco - 1000 foot sand
	PG-Hf 40	73-0298	Observation	28	832-842	1095	Patapsco - 850 foot sand
	PG-Hf 41	73-0297	Observation	28	616-626	675	Magothy
	PG-Hf 42	73-0294	Observation	28	336-346	395	Aquia
	PG-Hf 44	73-0065	Observation	11	1014-1019	1545	Patapsco - 1000 foot sand
	PG-Hf 45	88-1080	Production	45	805-1021	1102	Patapsco - 850 & 1000 foot sand
	PG-Hf 46	88-1079	Production	45	903-1009	1100	Patapsco - 850 & 1000 foot sand
	PG-Hf 47	88-1081	Production	45	810-1040	1103	Patapsco - 850 & 1000 foot sand
Morgantown	CH-Ee 68	67-0080	Observation	22	1057-1077	1152	Lower Patapsco
	CH-Ee 69	69-0089	Production	22	1051-1082	1152	Lower Patapsco
	CH-Ee 70	67-0081	Observation	23	1067-1092	1131	Lower Patapsco
	CH-Ee 71	69-0090	Production	22	1050-1086	1113	Lower Patapsco
	CH-Ee 72	69-0087	Production	22	1059-1095	1117	Lower Patapsco
	CH-Ee 73	69-0088	Production	22	1057-1092	1114	Lower Patapsco
	CH-Ee 78*	73-1965	Observation	75	1073-1124	1220	Lower Patapsco
Vienna	DO-Dh 27	71-0001	Observation	9	24-54	152	Columbia
	DO-Dh 28	71-0013	Production	10	26-46	67	Columbia
SMECO	PG-Hf 48	88-0569	Production	89	811-847	1100	Upper Patapsco (850 foot sand)
	PG-Hf 49	88-0568	Production	89	803-843	972	Upper Patapsco (850 foot sand)

Source: U.S. Geological Survey

* CH-Ee 78 became active in April 1993

Ground water withdrawals by each of the five power plants and their impact on Maryland's ground water resources are discussed in more detail below.

Calvert Cliffs Nuclear Power Plant

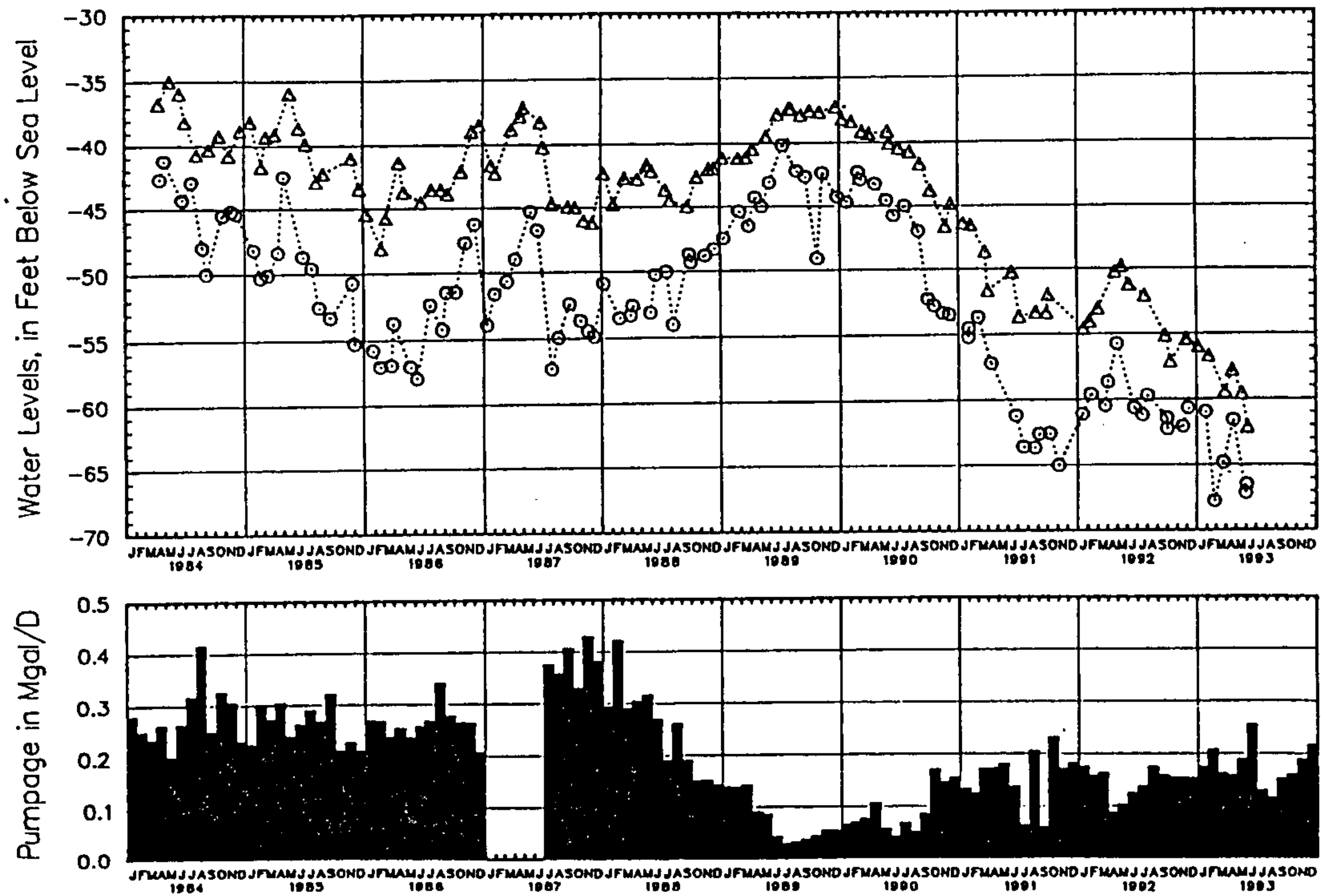
The Calvert Cliffs Nuclear Power Plant withdraws ground water from three production wells in the Aquia Aquifer at depths ranging from 403 to 563 feet below sea level (Table 3-9). Average daily ground water withdrawals by the plant were 0.15 and 0.18 mgd in 1992 and 1993, respectively (Table 3-8). These rates are similar to the 1991 level, and remained below the levels prior to the plant shutdown in 1989 and 1990.

Figure 3-21 illustrates the long-term monthly high and low water levels and withdrawal rates at the Calvert Cliffs power plant. Between 1984 and 1988, water level fluctuations correlate with pumping rates, suggesting that Aquia Aquifer water levels in the vicinity of the power plant were strongly influenced by plant pumping patterns. However, since 1989, the following data indicate that pumping at Calvert Cliffs has not directly affected the Aquia Aquifer:

- From July 1989 through 1991, water levels declined sharply by about 25 feet, even though pumping rates at the power plant remained low;
- During the first four months of 1992, water levels rose approximately 4 feet, although pumping rates generally remained consistent with those of late 1991; and
- From May 1992 through 1993, water levels declined 12 feet, despite the fact that the pumping rates at the power plant remained consistent with 1991 withdrawal rates.

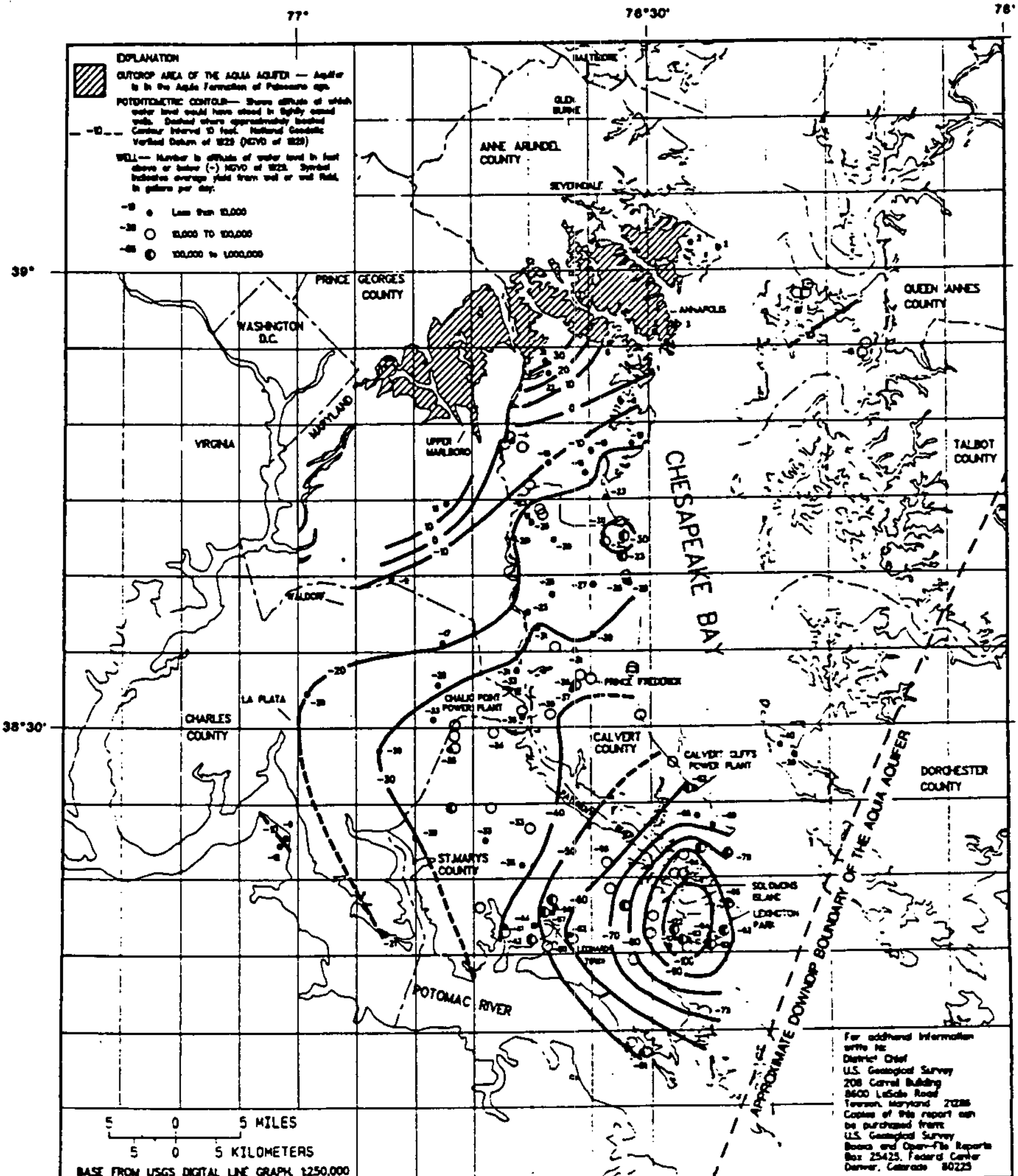
Figure 3-22 illustrates the **potentiometric surface** of the Aquia Aquifer in southern Maryland in September 1993, as determined from water level measurements in 81 wells within the PPRP/MGS/USGS monitoring network. Throughout most of southern Maryland, ground water in the Aquia flows southeast toward an extensive cone of depression around well fields at Lexington Park and Solomons Island. In 1993, ground water levels were more than 60 feet below sea level in a 200-square-mile area surrounding the deepest part of the cone of depression, and 124 feet below sea level in one well near the center of the cone. In 1990, ground water levels were more than 60 feet below sea level in a 90-square-mile area surrounding the deepest part of the cone of depression. Consequently, the areal extent of the cone of depression around Lexington Park and Solomons Island has approximately doubled since 1990.

Figure 3-21
Monthly Ground Water Pumpage and Water Levels in Observation Well CA-Ed 47 at the Calvert Cliffs Nuclear Power Plant from 1984 through 1993



Source: U.S. Geological Survey

Figure 3-22
Potentiometric Surface of the Aquia Aquifer in Southern Maryland, September 1993



Source: U.S. Departmentof the Interior, U.S. Geological Survey
Prepared in cooperation with Maryland Geological Survey and Maryland Tidewater Administration
Prepared by Stephen E. Curtin, Frederick K. Mack, and David C. Andreasen
Open-file Report 94-390

Figure 3-23 illustrates the change in the potentiometric surface of the Aquia Aquifer from 1982 to 1993. Monitoring of the Aquia Aquifer from 1982 to 1990 indicated that the potentiometric surface declined approximately 13 feet near Calvert Cliffs. From 1990 to 1993, the potentiometric surface declined an additional 17 feet for a total decline of 30 feet over 11 years. The decline in the potentiometric surface in the Lexington Park and Solomons Island area was greater than 40 feet between 1982 and 1993, which is an increase of 20 feet of decline since 1990.

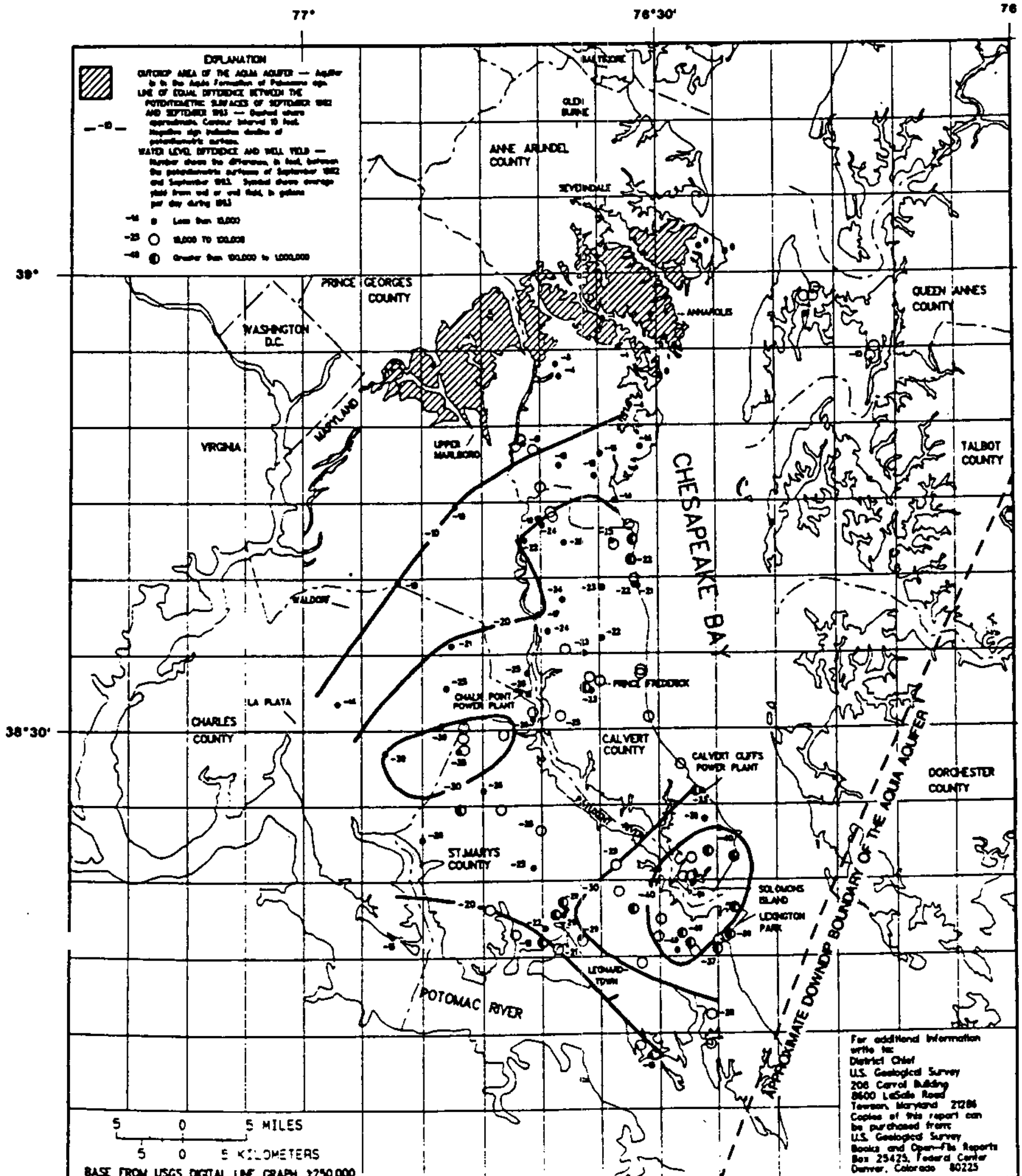
It can be concluded that ground water withdrawals in the Lexington Park and Solomons Island area are responsible for the recent decline in water levels at Calvert Cliffs. The increase in the areal extent of the cone of depression in the Lexington Park and Solomons Island area indicates that water levels in the Aquia Aquifer have not yet stabilized with pumping. Continued withdrawals at Lexington Park, Solomons Island, Calvert Cliffs, and in southern Calvert County in general are expected to cause further decline in the water levels in the Aquia Aquifer. However, the decline of 40 feet in the Lexington Park and Solomons Island area represents only 15% of the approximately 270 feet of available drawdown that remains in the Aquia Aquifer.

Chalk Point Power Plant

Chalk Point obtains ground water from five production wells in the Magothy Aquifer and four production wells in the Patapsco. Three of the Patapsco production wells began pumping in 1991 to serve the additional water demands of four new combustion turbines brought on line in 1991 and 1992. Wells in the Magothy are screened from 581 to 628 feet below sea level, while the Patapsco wells are screened from 805 to 1,054 feet below sea level (Table 3-9). Between 1992 and 1993, the average daily pumping rate from the Magothy Aquifer was 0.31 mgd and from the Patapsco Aquifer 0.44 mgd. Pumping rates from the Magothy Aquifer have decreased during the past 17 years from a high value of 0.95 mgd in 1976, in part because of concern over regional water level declines in the Magothy. This decline in PEPCO's pumping rates from the Magothy Aquifer has been offset by increased pumping rates in the Patapsco Aquifer since 1980.

Unlike the continuous sand units of the Aquia and Magothy Aquifers, the Patapsco Aquifer consists of several sandy units separated by low-permeability units. Water-bearing sand layers of the Patapsco have been identified in the Patapsco Aquifer at approximate depths of 850, 1,000, and 1,500 feet below the land surface (Mack 1988). In the vicinity of Chalk Point, there appears to be hydraulic connection between the 1,000-foot and 850-foot sand layers (Mack 1988), and together, the two layers are termed

Figure 3-23
The Difference Between the Potentiometric Surfaces of the Aquia Aquifer of September 1982 and September 1993 in Southern Maryland



Source: U.S. Departmentof the Interior, U.S. Geological Survey
Prepared in cooperation with Maryland Geological Survey and Maryland Tidewater Administration
Prepared by Stephen E. Curtin, Frederick K. Mack, and David C. Andreasen
Open-file Report 94-394

the Upper Patapsco Aquifer. The 1,500-foot sand layer is referred to as the Lower Patapsco Aquifer. At the Chalk Point power plant, the four production wells in the Patapsco withdraw water from the Upper Patapsco.

Figure 3-24 illustrates the monthly pumpage rates from the production wells and water levels in monitoring wells completed in the Aquia, Magothy, and Patapsco Aquifers at Chalk Point. Key water level information presented in Figure 3-24 for each aquifer is discussed below.

- *Magothy Aquifer* - Fluctuations in the water level measured in well PG-Hf 41 in the Magothy Aquifer during 1992 to 1993 generally amounted to less than 6 feet, and correlate with PEPCO's pumpage from that aquifer. The water level elevation in well PG-Hf 41 remained consistent with the elevation measured in 1989 and 1990, despite the decrease in PEPCO's withdrawals from the Magothy Aquifer from 0.54 mgd in 1989 to 0.25 mgd in 1993.
- *Patapsco Aquifer* - PEPCO's Patapsco withdrawals at Chalk Point increased from an average of 0.37 mgd in 1988 to an average of 0.46 mgd in 1989, and have remained approximately the same from 1989 through 1993. Water levels measured in Patapsco Aquifer well PG-Hf 40 have declined a total of about 3 feet from 1992 to 1993, and 8 feet since January 1989.
- *Aquia Aquifer* - Water level data from Aquia Aquifer observation wells PG-Hf 35 and PG-Hf 42 are also presented in Figure 3-24. While Chalk Point withdraws no water from the Aquia, the aquifer is monitored to detect any effects of ground water withdrawal from the underlying Magothy and Patapsco Aquifers. The monitoring results show that the water level in the Aquia Aquifer declined approximately six feet in both wells during 1992 to 1993, and a total of 10 feet since January 1989. This water level decline does not correlate with fluctuations in pumpage from the underlying Magothy Aquifer, indicating that Chalk Point withdrawals do not influence water levels in the Aquia Aquifer. Rather, the declines observed in the two Aquia monitoring wells at Chalk Point are consistent with the regional decline of the potentiometric surface of the Aquia Aquifer in southern Maryland (see Figure 3-23).

Figure 3-25 presents the relationship between the annual low water levels and the average annual ground water withdrawal from the Magothy Aquifer at Chalk Point for 1962 to 1993. This figure shows that after a steady decline from 1962 to 1984, the water level has remained consistent through 1993, and in fact may indicate a recovery between 1990 to 1993.

Figure 3-24
Daily Water Levels and Pumpage at Chalk Point Power Plant 1992-1993